## REMARKS

### 35 U.S.C. §102(b)

Applicants assert that the invention as claimed in the currently amended independent Claim 1 is not anticipated by the prior art.

In the Examiner's review of the present invention in light of the prior art, Applicants assert that the manner of implementation of elements within a device must be considered in making a determination of anticipation by other devices of the prior art. Particularly, in the review of a device conceived to combine vibration isolation capability with actuation capability, the consideration of equivalency of elements should also consider the manner of implementation of those elements within the device. The manner of load transfer between elements and the resulting stiffness of the load path effected are of significant importance to the viability of a device to serve as a hybrid isolator-actuator.

Applicants assert the coil and magnet and the application of the magnetic force between the two, as claimed and implemented within the present invention, is not anticipated through Terao's use of a motor. Importantly, in the present invention the magnetic force created between the coil and magnet is applied to the pneumatic actuator directly without intervening mechanical means. The electric motor within Terao, though it may include a magnet and coil, is not equivalent to the coil and magnet of the present invention. The electric motor in Terao drives the ball screw shaft of Terao through first and second rotating means. The ball screw shaft in turn mechanically engages the piston of Terao. The high stiffness of the ball screw and the combined inertias of the ball screw,

pulleys and motor prevent the Terao device from serving as an isolator.

Applicants further assert that the present invention as claimed in currently amended independent Claim 1 is not anticipated by Terao because of the present invention's incorporation of the carriage and housing wherein the carriage rides within the housing upon a gas film. By supporting the carriage on a gas film, the carriage can effectively move frictionlessly within the housing, and the sensed error in the commanded state variable error of the pneumatic actuator can be precisely negated and corrected through the direct application of the magnetic force.

In overview of the Terao patent, Applicants assert the Terao device is not a vibration isolator in design or intent, and Terao cannot be employed as a vibration isolator due to the stiffness of the ball screw and due to the inertia of the ball screw, motor, and pulley drive hardware. A view that Terao serves as an isolator is not supported by the text of the patent, and there is no language whatever within the Terao patent describing the device or indicating use as a vibration isolator.

/

35 U.S.C. §103(a)

Applicants assert that the invention as claimed in the currently amended independent Claim 1 is not rendered obvious by the prior art and not by Terao, Davis or Yamaoka, whether alone or in combination.

/

The invention as claimed in currently amended independent Claim 1 discloses a vibration isolation, position actuation device comprising a pneumatic actuator, a pressure servo-valve, a gas pressure supply, a coil and magnet, a state variable sensor, and a control unit wherein the pneumatic actuator is further comprised of a carriage and a housing wherein the carriage is constrained to move within the housing upon a gas film, wherein the pressure servo-valve accepts an input command signal and modulates the gas pressure supply which is applied to the pneumatic actuator, wherein the state variable sensor measures a state variable of the pneumatic actuator resulting from the applied modulated gas pressure supply, wherein the control unit determines the error existing in the measured state variable relative to the command signal, and wherein the control unit modulates electrical current applied to the coil such that a magnetic force is effected between the coil and magnet, wherein the magnetic force is directly applied to the carriage of the pneumatic actuator by the magnet without intervening mechanical means, in such proportion to negate the measured error in the state variable of the pneumatic actuator.

Terao teaches refined position control. Terao does not teach refined force control, as does the present invention, which is essential to providing combined isolation and actuation.

Terao teaches refined position control via combination of a ball screw engaged with an air piston. This combination results in a stiff load path, no vibration isolation, and little physical ability to add vibration isolation within the device. Further the ball screw of Terao is a primary element of that device and is claimed within Terao's independent claim number 1. It is an essential element to the operation of that device and

cannot be removed without eliminating any advantage the Terao device has over a simple pneumatic actuator, and the inclusion of the ball screw prevents the Terao device from offering any passive vibration isolation or force control.

The Terao device is not an isolator, but only an actuator; it is a position actuator comprising a ball screw operating in mechanically conjoined position with an air piston. The Terao device cannot control the force applied to the payload so to provide vibration isolation as well as position actuation. The Terao device does not incorporate a magnet and coil such that it may apply an error correcting magnetic force directly to the carriage of a pneumatic actuator, as does the present invention. The Terao device cannot make the applied dynamic force as large or as small as necessary to effectively isolate the workpiece or payload from vibrations in the mounting base of the device, as does the present invention.

Rather, Terao incorporates a ball screw and the ball screw applies an indeterminate mechanical force to the piston based on the desired workpiece position. The air piston initially positions and supports the static load of the table and any attached workpiece. The ballscrew then provides the final positioning of the workpiece. The Terao device, in using the ball screw to engage and provide final position of the piston and workpiece, suffers from the inherent stiffness of, and inability to backdrive the ballscrew. These attributes coupled with the low dynamic force response of the drive motors and pulleys prevent the Terao device from providing any significant vibration isolation capability.

Because of these features of the Terao device and to its significant limitation, the Terao device positions its workpiece regardless of the body accelerations that may exist

on the workpiece or the dynamic displacement disturbances at the base of support for the device. Because of the stiffness of the load path through the ball screw, the Terao device transmits whatever dynamic displacement disturbances the base experiences onto the workpiece.

The present invention provides vibration isolation at high frequency and also provides position control via force control through the error correcting application of a magnetic force of potentially zero stiffness directly to the carriage of the pneumatic actuator portion of the device. This has not been done before and the combination is not obvious. Within the broad flexibility of the present invention, as claimed in independent Claim 1, a variety of actuation state variables may be controlled in conjunction with broadband vibration isolation. In a preferred embodiment the present invention effects a force generation device. Its stiffness can be made as soft as desired simply by configuration of the force feedback loop managed by the control unit. At low frequency, it can have a stiffness approaching zero simply by commanding a constant force equal to the external static load. The Terao device has no such capability, and it does not teach or suggest such ability alone or in combination with any other device of the prior art.

The Terao device effects a static position control device whereas the presently disclosed invention effects a vibration isolation and dynamic force (or other state variable) control device. The Terao device, through use of the ballscrew accomplishes refined position control on the pneumatic cylinder, but it has very little bandwidth, i.e. it could not produce a position output that would accurately track an input signal if a command waveform called for it to move back and forth over a significant distance at a rate of more than, at most, a few cycles per second. The Terao device does not teach or

disclose application of a magnetic force to the pneumatic actuator in such proportion to negate the measured error in the state variable of the pneumatic actuator.

The Terao device neither discloses the particular elements of the invention as claimed in independent Claim 1 nor does it teach or suggest the combination of the elements and resulting advantages of the disclosed invention. Particularly, the presence of the electric motor driven ballscrew in the Terao device is not equivalent in elemental concept, application nor capability to the application of a magnetic force directly to the carriage of the pneumatic actuator via a coil and magnet through the modulation of an electric current applied to the coil. The ballscrew imparts substantial stiffness that prevents vibration isolation, and further the motor and drive add significant effective inertia to the device.

The Examiner asserts that Davis and Terao combine to render the present invention obvious. Applicants assert that Davis teaches damping modulation within an isolator and that Terao teaches refined position control within an actuator with concomitant and inherent exclusion of vibration isolation, and the combination of the two do not render the present invention obvious.

The Davis device utilizes an electromagnetic actuator to vary the pressure of the damping fluid used within an otherwise passive damping mechanism. The Davis device does not address actuation error control and it does not teach the implementation of non-contacting magnetic force on a pneumatic actuator. The Davis device does not teach the incorporation of a coil and magnet in combination with a pneumatic actuator for directly applying a magnetic force of such proportion to negate the measured error of the pneumatic actuator. The teaching of Davis, rather, is that only modest actuation is

obtainable from an isolator through the incorporation of an electromagnetic actuator within a concept directed towards damping modulation.

Device actuation state variable control, and particularly overall device output force control, is not provided by the Davis device. Applicants assert that Davis is not instructive on how such control could be implemented onto the Terao device. Within Davis, the utilization of an electromagnetic actuator for damping chamber shape change and resulting fluid pressure control does not render the present invention obvious in light of Terao. Davis does not utilize its electromagnetic actuator for error correcting magnetic force generation. Further, the Davis device does not incorporate pneumatic actuator elements or features for providing large stroke and load carrying capability, as does the present invention.

Yamaoka teaches an actuation means, but nothing of isolation and force control. The Yamaoka device uses electromagnetics to generate the entire actuation force developed by the device and incorporates no passive means for transmitting force from one end of the device to the other. Yamaoka discloses an electromagnetic strut and does not incorporate the elements or features of a large force pneumatic actuator. There is no teaching within Yamaoka for the effecting of a magnetic force in such proportion to negate the measured error in the state variable of a pneumatic actuator.

The Applicants assert that beyond the distinctions of teaching and concepts drawn, that the presently claimed invention as claimed in independent Claim 1 is non-obvious based on its distinct and marked improvement in performance relative to devices of the prior art.

The presently claimed invention provides significantly larger payload carrying capability, higher accuracy dynamic position actuation capability, as well as significant broadband vibration damping and isolation ability beyond the state of the prior art. The presently claimed invention can track a force command at rates of 20-40 cycles per second. The Davis device discloses a passive damping device that relies on arc shaped mechanical spring elements to support the isolated payload, thereby significantly limiting its load carrying ability. Further, the position actuation capability of Davis is limited to the modest loads and strokes afforded by the electromagnetic actuation portion of the device. The Terao device claims no isolation ability, and inherently has little effective vibration isolation capability, and incorporation of isolation features of Davis is not obvious.

Further, because within the present invention, as claimed in currently amended independent Claim 1, the pneumatic actuator is further comprised of a carriage and a housing wherein the carriage is constrained to move within the housing upon a gas film, the carriage is thus allowed to move frictionless within the housing of the actuator. The frictionless operation of the carriage allows the instantaneous pneumatic force to be exactly determined through measurement of a state variable of the pneumatic actuator, and thereby the magnetic force correction of the applied pneumatic force of the pneumatic actuator is highly accurate.

Applicants further argue that the bandwidth of vibration isolation, the degree of lifting force available from a device, as well as attributes such as range of stroke, are not features of a device but performance characteristics to which it can be compared to devices of the prior art. Thereby such performance attributes do not need to be claimed

as features of the device. And therefore vibration isolation bandwidth performance is not moot to a determination of non-obviousness, and Applicants assert in consequence that the presently claimed invention is non-obvious for the substantial performance improvement it gains in isolation bandwidth performance combined with large force and stroke capabilities when viewed relative to devices of the prior art.

Because of the above described distinct, novel, and non-obvious differences of the present invention relative to Terao, Davis, and Yamaoka, and because of the significant performance advantages and improvements provided by the present invention relative to the prior art, Applicants assert that the present invention as claimed in currently amended independent Claim 1 is not obvious in light of the prior art and is not obvious in light of Terao, Davis, and Yamaoka when considered alone or in combination.

## CONCLUSION

For the above reasons Applicants request that the present invention as claimed in the currently amended independent Claim 1 be considered not anticipated by the prior art and not obvious in light of the prior art, and that dependent claims 2, and 4-6 are allowable as being dependent upon currently amended base Claim 1. Dependent claim 3 is requested concomitantly to be canceled.

Respectfully submitted,

1/26/05

Rick G. Brewster

USPTO Reg. No. 35,077